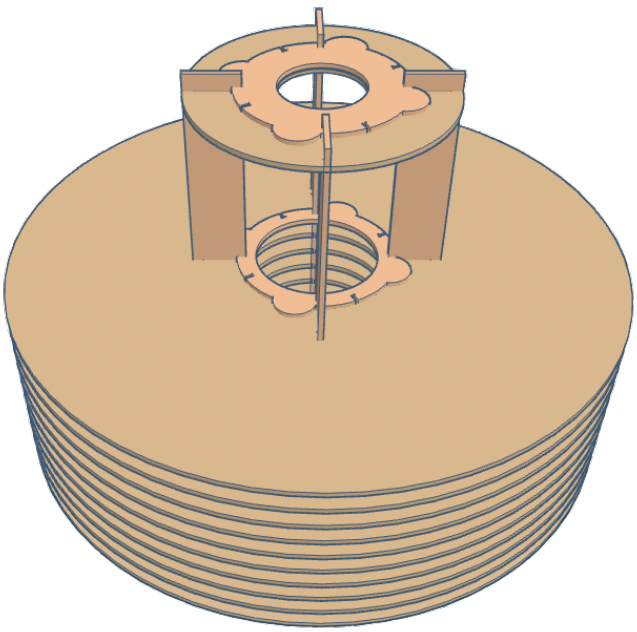
<OPEN-SOURCE UPPER-ROOM UVGI FIXTURE >

DESIGN SPECIFICATION

Version *<1.0>*

[April/3/2022]



PROJECT OUTLINE

1. BACKGROUND

Since the first case of SARS-CoV-2 was identified in Wuhan, China, in December 2019, mitigation efforts have invariably been reactive- every small delay giving the virus a chance to establish a foothold. Poor messaging about the efficacy of masks, and mask shortages caused tremendous loss of life. Later, poor compliance caused by that messaging greatly reduced the effectiveness of masks due to insufficient adoption and active resistance by members of the public. Vaccination efforts encountered similar difficulties and a high level of non-compliance.

New measures are clearly needed that did not require the active participation of the public. If the virus were a thinking opponent, we would seek cut its OODA loop, preempt it, be where it would be- not just where it was, before it had become too widespread with too many actively shedding carriers to fight effectively. While it is not sentient the same proactive strategy applies.

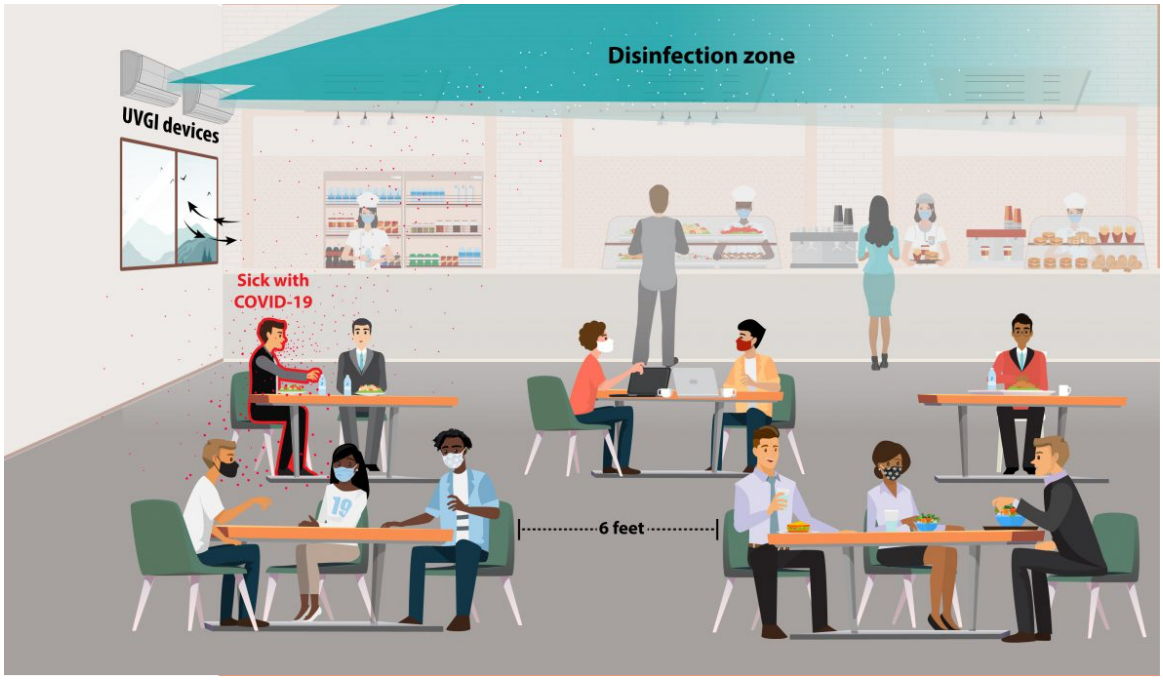
Within North America, measures like CO2 monitoring, and the novel Corsi-Rosenthal Box fit this role admirably. But the materials for the Corsi-Rosenthal Box are hard to obtain outside of North America and the cost of ownership is approximately $30-$40 USD a month in filters and power- this is a considerably sum in much of the world.

The Corsi-Rosenthal Box is also quite large and noisy- while entire families living, and studying in one or two small rooms is a global norm. There are smaller variants to consider but these still use costly to replace filters and are less efficient than larger versions.

Air filtration is an invaluable tool- but it is not the only tool for addressing indoor air quality and viral load. We need to use every measure at our disposal if we want to cut that loop and preemptively hit the virus before it gains a foothold in ultra-high density, low-income housing that often has low vaccination levels and little access to medical care.

In these environments- Bhalswa Village in Delhi, Tondo in Manilla, Neza-Chalco-Itza in Mexico City, Hong Kong "coffin houses", factory worker dormitories throughout China, South, South-Eat Asia, and countless other places; there is limited ventilation, limited space, and proximity to fecal aerosol transmission routes. Isolation once infected is rarely a possibility. The circumstances are so dire, the infection and mortality rates so high that even the most modest interventions can save countless lives.

One such measure, uniquely suited to this use case is Upper Room UVGI. It's well studied, evidence-based, safe when properly implemented- and if the goal of this project is achieved, we propose to make it cost effective as well.



While the conditions in dense, low-income urban housing may make mitigation seem hopeless, in truth, the nature of those conditions make UR-UVGI ideal. A communal latrine in a developing country is often our "Broad Street pump handle".

Even a single UR-UVGI fixture mounted in such a community washroom, or in shared hallway leading to poorly ventilated rooms can lower the infection rate for hundreds of people. UR-UVGI has a staggeringly high ROI under these conditions- and our "return" is paid in saved lives.

2. THE GOAL

This Open-Source Hardware project will enable low-cost, field expedient and cottage-manufacturing based fabrication of UR-UVGI fixtures from almost entirely local materials, built and installed with local labor- with the potential for a sustainable business model for those locals in the future as the fixtures prove themselves.

The required 254nm radiometer and ozone detector costs $260 and $90 respectively- and funds have already been set aside to donate these tools to several installation teams around the world. Suitable laser cutters are used makerspaces, universities, and in sign making shops in every major city in the world.

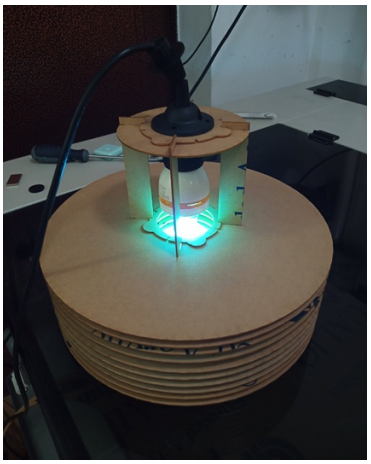
Any individual able to exercise the level of care required to work on mains electricity, and power distribution boxes will have no problem learning- within a few hours, how to work with UVC and the required testing tools for a safe installation in compliance with international standards.

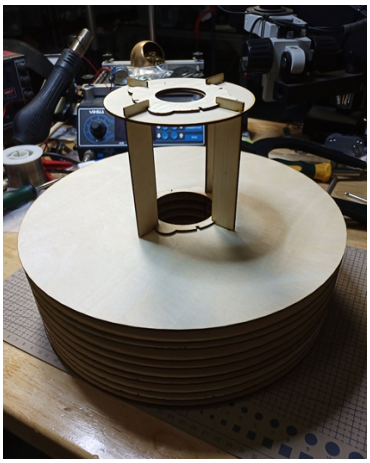
The end-goal is to make the local market for these devices self-sustaining and as independent of the global supply chain as possible. With a large enough user base- with the goal of making UR-UVGI as ubiquitous even in low-income homes as a rice cooker and oscillating fan, respiratory viruses of all varieties will encounter far greater resistance to transmission.

Unlike masks, UR-UVGI does not require mass adoption to be most effective, but it certainly would benefit from it. We can do that by making them cheap, commercially viable outside of a charitable initiative, and by working with local partners people trust.

3. THE PROJECT

Right now, we have a working, tested UR-UVGI fixture ready to deploy- with some caution.





Each fixture requires 1.27m2 of 2mm material, and costs about $20USD to make in China, and an estimated $25USD-$30USD in most of Asia.

Shenzhen material costs (retail):

Laserply (wood): $8.00USD

E27 socket + cord with switch: $3.00USD

36W 254nm UVC CFL (mercury vapor): $9.00USD

The CFL bulb would need to be replaced about once a year at a cost of $10. Power would cost approximately $2-$3 per month for 24 hour usage. Each lamp requires 5-10 minutes to assemble and probably 15-20 minutes to install.

Individual homeowners should be discouraged from attempting installation themselves due to the risks inherent in UVC.

4. NEXT STEPS

- Confirm ozone output of current specified mercury vapor bulb stays below OSHA/NIOSH limit of 0.1ppm in 10 m^3 room.
- Consult appropriate experts as to the advisability of raising the exposure limit from 0.2-0.3µW/cm2 for greater efficacy (See https://doi.org/10.1111/php.13402).
- Send initial installation teams sample fixture, 254nm radiometer, and supply of UVC lamps for test fabrication and deployment (now determining feasibility with Shanghai and Hong Kong).
- Create database/spreadsheet with details of each installation location. Contact method, family name, room dimensions, address + geo-coordinates (traditional addresses can be difficult in some of these environments). Purpose is follow-up studies and in the event the fixtures need to be recalled for safety reasons. Real-world room dimension data can be used to fine tune the fixture design- possibly with software designed for the purpose like Photopia™. Potentially also for directly compensating installers in particularly low-income areas.
- Network with in-country, on-location academics, contact tracers and community leaders to find our “pump handles”- places that have repeatedly been cited as branching off points in transmission chains. Either specific locations, or location types that we may be unaware of due to different local customs and living arrangements. If local contact tracing protocols are insufficiently granular (or non-existent), high CO2 counts in high-traffic public spaces that cannot be easily ventilated may help us find these places and appropriate metering equipment should be supplied. Laundry rooms, off-books childcare, ghost kitchens, home-churches, sex work facilities- every neighborhood has its own character we don’t know what we don’t know- and locals do.

INFORMATION

"Influencer" Introduction video for the public:

https://youtu.be/QSnUce9xdNo

Corsi-Rosenthal Box

https://cleanaircrew.org/boxfanfilterfaq/

https://edgecollective.io/airbox/

UVG

Rapid and complete inactivation of SARS-CoV-2 by ultraviolet-C irradiation

https://www.nature.com/articles/s41598-020-79600-8

Not all wavelengths are created equal: disinfection of SARS-CoV-2 using UVC radiation is wavelength-dependent

https://doi.org/10.1099/acmi.0.000276

https://www.microbiologyresearch.org/content/journal/acmi/10.1099/acmi.0.000276

ASHRAE: Ultraviolet Germicidal Irradiation Current Best Practices

https://www.ashrae.org/file%20library/technical%20resources/covid-19/martin.pdf

A Need to Revise Human Exposure Limits for Ultraviolet UV-C Radiation

https://doi.org/10.1111/php.13402

https://onlinelibrary.wiley.com/doi/full/10.1111/php.13402

How Do UV Light Air Purifiers Work and Can They Kill Viruses?

https://smartairfilters.com/en/blog/uv-light-air-purifiers-uvgi-far-uv-covid-delta-virus/

Ultraviolet Germicidal Irradiation Safety Concerns: A Lesson from the Tuberculosis Ultraviolet Shelter Study Murphy's Law Affirmed

https://doi.org/10.1111/php.12034

https://sci-hub.hkvisa.net/10.1111/php.12034

Upper Room UVGI

CDC: Upper-Room Ultraviolet Germicidal Irradiation (UVGI)

https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation/uvgi.html

Upper Room Germicidal Ultraviolet Systems for Air Disinfection Are Ready for Wide Implementation

https://doi.org/10.1164/rccm.201505-0927ED

https://www.atsjournals.org/doi/10.1164/rccm.201505-0927ED

Air Disinfection for Airborne Infection Control with a Focus on COVID-19: Why Germicidal UV is Essential
https://doi.org/10.1111/php.13421

https://onlinelibrary.wiley.com/doi/10.1111/php.13421

Engineering mitigations limit infection from COVID-19

https://www.csemag.com/articles/engineering-mitigations-limit-infection-from-covid-19/

Environmental Control for Tuberculosis: Basic Upper-Room Ultraviolet Germicidal Irradiation Guidelines for Healthcare Settings

https://www.cdc.gov/niosh/docs/2009-105/pdfs/2009-105.pdf

Upper room ultraviolet germicidal irradiation (UVGI) system

https://medicalguidelines.msf.org/viewport/TUB/latest/appendix-19-upper-room-ultraviolet-germicidal-irradiation-uvgi-system-20324482.html

Upper-room ultraviolet air disinfection might help to reduce COVID-19 transmission in buildings

https://doi.org/10.1101/2020.06.12.20129254

https://www.medrxiv.org/content/10.1101/2020.06.12.20129254v1.full

Safety of Upper-Room Ultraviolet Germicidal Air Disinfection for Room Occupants: Results from the Tuberculosis Ultraviolet Shelter Study

https://dx.doi.org/10.1177%2F003335490812300108

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2099326/

2016 ASHRAE Handbook—HVAC Systems and Equipment

CHAPTER 17 - ULTRAVIOLET LAMP SYSTEMS

https://www.ashrae.org/file%20library/technical%20resources/covid-19/i-p_s16_ch17.pdf

Germicidal UV Upper-Air - Commissioning and Ongoing Maintenance Measurement Guidelines

https://www.assets.signify.com/is/content/Signify/Assets/alkco/20210428-commissioning-and-ongoing-maintenance-measurement-guidelines.pdf

Numerical Investigation of Upper-Room UVGI Disinfection Efficacy in an Environmental Chamber with a Ceiling Fan

https://doi.org/10.1111/php.12039

https://sci-hub.ru/10.1111/php.12039

Fecal Aerosol Transmission

CDC Fecal Source Transmission

https://www.cdc.gov/library/covid19/pdf/2020-09_08-Science-Update_FINAL_public-v2.pdf

Probable Evidence of Fecal Aerosol Transmission of SARS-CoV-2 in a High-Rise Building

https://www.acpjournals.org/doi/10.7326/M20-0928

Infectious SARS-CoV-2 in Feces of Patient with Severe COVID-19

https://wwwnc.cdc.gov/eid/article/26/8/20-0681_article